# BLOCKCHAIN READINESS ASSESSMENT FOR MALAYSIAN ORGANIZATIONS AND CHALLENGES TO ADOPT BLOCKCHAIN TECHNOLOGY

By:

**TEOH CHIN XUAN**

(Matrix no.: 138298)

Supervisor:

**Mr. Mohzani Mokhtar**

July 2021

This dissertation is submitted to
Universiti Sains Malaysia
As partial fulfilment of the requirement to graduate with honours degree in
**BACHELOR OF ENGINEERING**
**(MANUFACTURING ENGINEERING WITH MANAGEMENT)**


School of Mechanical Engineering

Engineering Campus

Universiti Sains Malaysia

## DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed: …… (Teoh Chin Xuan)

Date: ……16 July 2021……...

Statement 1

This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by giving explicit references. Bibliography/references are appended.

Signed: ……... (Teoh Chin Xuan)

Date: ……16 July 2021……

Statement 2

I hereby give consent for my paper, if accepted, to be available for photocopying and for interlibrary loan, and for the title and summary to be made available outside organizations.

Signed: ……. (Teoh Chin Xuan)

Date: ……16 July 2021…….

## ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude and special thanks to my supervisor, Mr. Mohzani Mokhtar for his continuous encouragement, precious advice and useful guidance along the whole project journey which eventually lead to the completion of this project. From time to time, he guides me patiently and provides me a lot of suggestions and advices to ensure that the progress is always on the right track until the end of the project.

Apart from that, I would also like to acknowledge with much appreciation to the course coordinator, Dr. Muhammad Fauzinizam Bin Razali who has invested his full effort in planning, arranging and conducting various seminar talks which are very helpful for our project. Many thanks go to those presenters who shared their knowledge with me to enhance thesis writing skill. Besides, I would really appreciate the comments and suggestions that will be given by my project examiner, Dr. Hasnida Ab Samat during the coming project presentation/viva.

Next, special thanks go to Associate Professor Ir. Dr. Chin Jeng Feng who assists me in distributing and sharing my questionnaire form to his friends in the industries that help to increase the number of responses for my project. Subsequently, I would like to show my most sincere appreciation to all the respondents who willing to spend time in providing feedbacks and fill in my survey form. Indeed, the responses collected serve as precious asset for the completion of this project.

Additionally, I would like to thank my family members and friends who encourage and help me throughout this research work. They showed unconditional support and attention for me through the highs and lows of this project.

Last but not least, I would like to show my full gratitude to School of Mechanical Engineering, University of Science, Malaysia (USM) for providing a platform to complete my Final Year Project (FYP) as well as my four years' university studies as an engineering student.

## TABLE OF CONTENTS

## LIST OF TABLES

**Page**

## LIST OF FIGURES

**Page**

## LIST OF SYMBOLS

| | |
|---|---|
| $W_1$ | weighting factor for question 1 |
| $\sum W$ | Sum of weighting factors of all 22 questions |
| $Q_1$ | Weighted mean of the responses from question 1 |
| $p_{1,i}$ | Responses from managers for question no. 1 |
| $r_{1,i}$ | Responses from users for question no. 1 |
| $W_{manager}$ | Weighting factor for manager |
| $W_{user}$ | Weighting factor for user |
| $n_{manager}$ | Number of respondents from a company who is manager |
| $n_{user}$ | Number of respondents from a company who is user |
| $Q_1$ | Weighted mean of the responses from question 1 |
| N | Population number |
| Z | Z-score |
| p | sample proportion |
| e | margin of error/confidence interval |
| $S^2$ | sample readiness score variance |
| $x_i$ | the readiness score of an organization |
| $\bar{x}$ | the mean readiness score of all 8 organizations |
| $n$ | the number of organizations involved |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| AI | Artificial Intelligence |
| BRI | Blockchain Readiness Index |
| DLT | Distributed Ledger Technology |
| DOI | Diffusion of Innovation |
| EHR | Electronic Health Records |
| EMS | Electronic manufacturing services |
| FRID | Radio frequency identification |
| GPS | Global positioning system |
| HDD | Internal hard disk drives |
| ICT | Information and communications technology |
| IoT | Internet of Things |
| IR4.0 | Industry Revolution 4.0 |
| OPEX | Operational expenses |
| R&D | Research and development |
| ROI | Return on Investment |
| SMEs | Small-Medium Enterprises |
| SSD | Solid state drives |
| TAM | Technology Acceptance Model |
| TOE | Technology-Organization-Environment |
| TRL | Technology readiness level |
| USM | Universiti Sains Malaysia |
| UTAUT | Unified Theory of Acceptance Model |

## LIST OF APPENDICES

## ABSTRAK

Blockchain merupakan teknologi yang mampu menghasilkan kesan kepada banyak industri dan organisasi serta cara hidup manusia sekarang. Teknologi blockchain mempunyai banyak faedah seperti memberikan ketelusan, penjimatan kos dan keselamatan. Walau bagaimanapun, penyelidikan dan analisis yang mendalam mengenai tahap kesediaan harus dilakukan sebelum blockchain dapat dilaksanakan secara meluas di Malaysia kerana tahap kesediaan yang telah diketahui awal dapat membantu menerapkan teknologi dengan lancar. Kajian ini bertujuan untuk mengira dan membandingkan skor kesediaan dalam kalangan organisasi Malaysia mengenai penerimaan dan penggunaan teknologi blockchain dalam perniagaan mereka, mengenal pasti dan menganalisis cabaran yang dihadapi oleh mereka, serta mencadangkan beberapa nasihat praktikal untuk mencapai pengoptimuman teknologi blockchain berdasarkan kesediaan tahap dan kesukaran yang dihadapi mereka. Metodologi penyelidikan dimulakan dengan tinjauan sistematik literatur berkaitan blockchain melalui carian dalam talian mengenai artikel jurnal. Setelah perancangan projek selesai, borang soal selidik dibina untuk mengumpulkan data kuantitatif dan kualitatif daripada responden organisasi Malaysia. Selepas itu, skor kesediaan akhir dikira menggunakan formula purata berwajaran dan pemetaan linear. Hasilnya menunjukkan bahawa keseluruhan skor kesediaan blockchain dalam kalangan organisasi Malaysia berada di bawah tahap purata (46.3%). Organisasi C menduduki tempat nombor satu dengan skor kesediaan tertinggi sementara organisasi D mempunyai skor kesediaan terendah. Cabaran utama ialah kemungkinan ancaman keselamatan dan kekurangan bakat blockchain. Motivasi utama ialah peningkatan ketelusan dan kecekapan dengan mewujudkan kelebihan daya saing. Kemahiran pengkomputeran IT, pengetahuan pengaturcaraan, inovasi, kemahiran analitik yang kuat, standardisasi peraturan, kualiti pengurusan data, latihan yang diberikan adalah antara kemahiran dan strategi penting untuk mengekalkan kejayaan teknologi blockchain pada masa depan. Batasan kajian ini adalah pengurangan kuantiti jawapan yang berjaya dikumpulkan daripada responden kerana pergerakan terhad semasa pandemik Covid-19 ini. Kesimpulannya, objektif tercapai pada akhir projek ini. Kajian ini memberikan pandangan kepada pembaca mengenai tahap kesediaan dan pandangan semasa dalam kalangan organisasi Malaysia terhadap teknologi blockchain serta menyediakan sumber rujukan kualiti yang berguna bagi para praktisi yang berminat dengan teknologi blockchain.

## ABSTRACT

Blockchain as an inspiring emerging kind of technology, is capable to create disruptive effects to many industries and organizations as well as the existing way of human life now. Blockchain technology comes with many benefits in the form of providing transparency, reducing costs, immutability and security. However, an in deep investigation and analysis about readiness level have to be conducted before blockchain can be widely implemented in Malaysia as pre-determining readiness level and challenges will help to adopt the technology smoothly. This study aims to calculate and compare the readiness score among Malaysian organizations on the acceptance and adoption of blockchain technology into their businesses, identify and analyse challenges faced by them, as well as to suggest some practical advices to achieve optimization of blockchain technology based the readiness level and difficulties they had. The research methodology starts with a systematic review of the blockchain related literature through online searching for the journal articles. After project planning was done, a questionnaire was constructed for collecting both quantitative and qualitative data from the respective Malaysian organizations' respondents. Subsequently, the final readiness scores were calculated using weighted mean and linear mapping equations. The results indicate that the overall blockchain readiness score among Malaysian organizations is at slightly below average level (46.3%). Organization C ranked number one with highest readiness score while organization D has lowest readiness score. The major challenges are possible security threat and lack of blockchain talent. Key motivations are transparency and efficiency improvement with creation of competitive advantages. IT computing skill, programming knowledge, innovation, strong analytic skill, standardize regulation, data management quality, training provided are among the essential skills and strategies for keeping up the future success of blockchain technology. The limitation of this study is the reducing of range and quantity of responses that had been successfully collected from respondents due to restricted movement during this Covid-19 pandemic. Generally, the objectives were achieved throughout the end of this project. This study provide insight to readers about the current degree of preparedness and point of views among Malaysian organizations towards the blockchain technology as well as provide a useful quality reference source for practitioners who are interested in blockchain technology.

# CHAPTER 1

# INTRODUCTION

## 1.1 Project Background

The main feature or technology being discussed and analyzed in this project is blockchain. A blockchain is a type of technology that can manage storage of data using database system while a database is defined as a collection of information which is being stored on a computer system electronically. Additionally, a database system can be designed to store huge amounts of information that can be instantly accessed and manipulated by any numbers of users simultaneously (Clohessy & Acton, 2019). The relationship between them is defined by all blockchains are databases but not all databases are blockchains.

Theoretically, the working principle of a blockchain is by collecting information together in groups, also known as blocks, that hold sets of information or data as well as provide certain storage capacities (Carlo R.W., 2020). When a block is filled, it is being chained onto the previously filled block, forming a chain of data known as the "blockchain" (LUKE CONWAY, 2021). In general, the blockchain is a chain of blocks or transaction which is mutually prolonged by every participating node through the network while the blocks are leashed together cryptographically. In fact, each block is digitally signed and contained the hash value of the previous block ( Ahmed & Khan, 2020).

The existing transactions data cannot be altered or deleted because new blocks can only be adjoined to the very end of the whole chain. This feature and characteristic of blockchain is considered as one of the various advantages of applying blockchain technology, which is immutable data inside the blockchain system. Besides, smart contract is another technologically tools being utilised in blockchain system. Smart contract is a computer protocol which usually used for checking the authenticity of a transaction and it makes the process easier and secured by performing the digital processing and verifying. Smart contract permits each other to make dependable, controlled and irrevocable transactions online. The aim of smart contract is to provide security and transparency among the stakeholders while performing any transactions

by removing trust needed in order to reduce the transaction time (Ahmed & Khan, 2020).

Industry Revolution 4.0 (IR4.0) is related to blockchain as blockchain is considered as one of the technology to be implemented in order to work well with other technological aspects of IR4.0 such as Internet of Things (IoT), big data and artificial intelligence (AI) technology. IR4.0 helps in the creation and improvement of new technology as well as creating smart industries with the utilization of IoT. The main aspects of industry 4.0 is an integrated system which consists of various IoT devices, cloud computing, and big data analysis. Indeed, information safety, trust, privacy and security are the primary concerns while considering the interoperability of Industry 4.0 across the network. For instance, there are numerous smart applications in smart city infrastructure constructed based on IoT devices. These applications make urban people's life to be more convenient.

Apart from its benefit, IoT based applications have some serious security issues ranging from functional, data, platform, device, cloud to network security (Ahmed & Khan, 2020). To solve these issues, blockchain act as distributed ledger technology (DLT) is gradually seen as a promising solution to help facing these challenges in a special and decentralized way. The distributed feature of blockchain allows the organizational entities and various IoT devices to exchange data from peers to peers, thus eliminating the centralized operational requirement (Carlo R.W., 2021). Hence, blockchain enables users of 5G IoT networks to interact and do transaction with secured data provenance and authenticity, accountability and immutability for every user and thus help to alleviate the security, privacy and scalability concerns associated with IoT, by building trust among each stakeholder, cost reduction and the acceleration of transactions speed, by eliminating central participants (Carlo R.W., 2021).

In recent years, IoT has emerged as a network of internet connected devices which range from simple consumer-devices to heavy industrial machines. IoT involves all sensing, monitoring, and exchange of data, followed by efficient data storing and processing using technologies like cloud computing (Carlo R.W., 2021). In the meantime, the IoT has provided many services in the fields of intelligent transportation, smart cities, medical treatment, smart agriculture and many others (Carlo R.W., 2021). Generally, these IoT-based solutions allow the automation of daily tasks and enable

effective monitoring and control of the connected devices which will result in improved efficiency and update the quality of life following convenience in performing daily life tasks (Blockchain, IoT and 5G, 2021).

Despite there are plenty of advantages and benefits promised by blockchain implementation, blockchain technology is still considered as nascent technology that not much industries started investigate and show interest towards this technology or do planning for fully widespread implementation around the world. This is mainly due to some challenges and barriers exist which cause the slow diffusion of blockchain technology into or among various industries. First and foremost, the public's knowledge and understanding level about this technology is still very low and there is some misunderstanding and negative impression towards blockchain technology. People's first impression about blockchain is always linked with cryptocurrencies such as Bitcoin and Ethereum since there are so many negative image about cryptocurrency such as fraudsters or hackers who commit cybercriminal activities using this technology. Public does not aware about the differences between bitcoin with blockchain.

In fact, blockchain technology can be implemented on many other field while cryptocurrencies are only one of the many applications of this technology. This perception will definitely inhibit the development process of blockchain technology and thus decrease the willingness to invest on and implement this technology (Carlo R.W., 2020). On the other hand, Covid-19 Pandemic which is viewed as biggest virus infection disaster to mankind so far had greatly affected the status of blockchain development in this year 2021. According to (Blockchain Trends in 2021, 2020), the global blockchain market size will grow exponentially following the pandemic which affected the whole world. Businesses from various industries showed a growing interest to adopt this technology for enhancing their business processes after the profit loss due to some movement lockdown within the outbreak (Ashley Younker, 2020).

The COVID-19 pandemic accelerated the digital transformation drive in many areas via the use of blockchain distributed ledger technology to manage manipulate their data effectively especially related to supply chain issues (Antal et al., 2021). Due to the increased strain that the COVID-19 pandemic put on daily business, corporates are trying to accelerate their digital transformation process to emerge stronger than

before so that they can cope well with the predicament faced by them during this pandemic (Abd-alrazaq et al., 2021). In such a case, blockchain technology will be very likely to make the most transformative and positive changes in the way businesses function in the near future (Carlo R.W., 2020).

However, there are still many obstacles that obstruct the implementation of blockchain technology. The organizational size affects the readiness and ability of the company to adopt new technology into their legacy system. Larger firm size with greater financial ability might have higher chance to get interested on new technology and process to adopt it. Meanwhile, smaller capacity firm does not have adequate modals to educate their employees or invest money in blockchain technology implementation. Organizations with current processes are always more cautious with the purchase of new innovations due to many factors that might interrupt the legacy system (Post et al., 2021). Furthermore, most of the organizations do not want to outsource projects because if this is the case, they will not learn how to handle the technology, leading to them being solely dependent on third-party organizations (Post et al., 2021). This made them become the technology user but not technology creator and will cause them to become less competitive compared to other large firm.

In order to investigate and analyze the potential development of blockchain technology among the industries, readiness level among the stakeholders has to be determined other than challenges and difficulties that they face. Generally, technology readiness level (TRL) is defined as an approach for understanding the technical maturity of a technology during its acquisition phase (TWI Ltd, 2021).

## 1.2 Project's Objectives

There are three main objectives for this project:

1) To calculate and compare the readiness score among Malaysian organizations on the acceptance and adoption of blockchain technology into their businesses.

2) To identify and analyze the challenges faced by the organization entities which inhibit the implementation of blockchain technology.

3) To relate and suggest some practical advices and appropriate next steps to achieve optimization of blockchain technology within organizations.

## 1.3 Problem Statement

An in deep investigation and analysis have to be conducted before a nascent and emerging technology can be widely implemented. There are many aspects and perspective of blockchain technology that can be investigated ranging from technical aspects to cultural aspects. Both technical and non-technical aspects should be emphasized on research work that are related to blockchain technology. Anyway, the existing research show a predominant focus on the technology perspective, which emphasize on blockchain technology diffusion which is the way to implement blockchain into the existing system. Moreover, some research focus on the advantages gained by organizations by leveraging the technology and some specific use cases or a specific part of blockchain technology.

As a matter of fact, there are more important aspects that worth to do research on them before deciding the implementation of certain technology. Readiness level, difficulties, shortcoming, and challenges among the organizations are good parameters to investigate on. In general, change readiness can be defined as the attitude and willingness of people towards the acceptance of a certain changes. They need to be clearly understand the consequences after the changes was made and is able to cope with any strain being put on them after that.

Pre-determining readiness level and challenges will help to adopt the technology based on every stakeholders' preferences and new technology being synced well with the legacy system. With that, they can fully enjoy the benefits provided from this technology implementation because the careful plan might help to minimize any side effects or long term effects generated after the implementation. Accordingly, this project will focus mainly on determining, computing and relating the readiness level of some organization entities in Malaysia with the challenges that they face regarding the adoption of this disruptive technology, blockchain that might potentially change their perspectives towards the transformation and evolution of data management system.

## 1.4 Scope of Project

This paper consists of total of five main chapters. It mainly covers the finding and reading of existing scientific journal or any other related papers from the online sources, planning research work that can fill the gaps of the existing research papers, studying several aspects of readiness level, distributing survey form to various Malaysian organizations to collect primary data, computing readiness level mark as secondary data, discussing and analyzing the challenges faced by respondents and convert it into secondary data to relate with the readiness level among respondents, discussing about some potential countermeasures to alleviate the challenges, discovering limitations of research as well as suggesting some improvement that can be made on the future works. Malaysian organizations are referring to any organizations in Malaysia whether are private or public sectors and they include any working fields/industries type such as healthcare, manufacturing/engineering, educational and banking.

The remainder part of the paper is constructed as follows. In next section, Chapter 2 covers all the topic-related literature that is available in online sources for not more than five years from the present year. It indicates awareness of previous framework that is relevant to this project's problem and describe theory, method, tools as well as existing solution associated with the problem area. Most importantly, it shows that this project is a research work that can fill up the gaps in the literature review section. Next, Chapter 3 describes the research methodology being applied in this project with including an overview diagram of solutions for the ease of reader to get the overall structure of the solution. Chapter 4 will include the results and discussion of the research finding which will cover the interpretation of data and include variations from the original plan. Last but not least, Chapter 5 draws a final conclusion and propose a better future work based on the current limitations of this project.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Overview

In this chapter, existing literature were reviewed and divided into three main fields which are trend and implementation of blockchain technology, blockchain readiness level assessment and lastly the challenges in technology implementation. From the review of the literature studies, several gaps were revealed. First and foremost, no previous research was found to have done the blockchain readiness assessment for the Malaysian organizations. Secondly, those studies had a weak emphasize regarding the proposed and suggested practical advice or solutions to the organizations based on their overall readiness level at the end of the research. Moreover, the result of readiness level was not discussed and associated closely with the challenges and difficulty faced by the organizations.

Regardless of these gaps, careful and in deep syntheses of those studies had provided basic understanding about the fundamental concept and background of blockchain technology. In addition, the trend, behaviour, technological aspects, application in various use cases, advantages and concerns regarding regulatory, privacy and security issues were also explored (Balasubramanian et al., 2021). Hence, the review provided an initial conceptual base for the development of the blockchain readiness assessment framework for Malaysian organizations (Balasubramanian et al., 2021). Readiness level assessment done on other countries in specific industry was referred as a guideline to carry out this project too. It helped to predict the final outcomes of this research work and contributed in creation of a systematic and standard survey questionnaire. The last section of this chapter shows the summary list of authors and their respective methodology used, primary focus and research objectives.

## 2.2 Trend and Implementation of Blockchain Technology

Blockchain technology had been adopted in various field regardless of its uncertain future potential. There is trend where the rate of implementation of blockchain technology is increasing year by year worldwide due to some advantaging factors. The following texts will explain the development and current status of

blockchain technology being applied in healthcare sector and supply chain management in several manufacturing sector.

### 2.2.1 Healthcare Sector

Recently, healthcare had started to receive more attention on blockchain enabled use cases. The potential of using blockchain technology to cope with existing challenges in healthcare applications had been highlighted by some researchers in their research writing (Ahmed et al., 2020). Blockchain is rapidly known for a large interest in the healthcare sector although public always associated blockchain with cryptocurrency and bank sector in its early adoption phase. Blockchain provides three of the most significant features that are beneficial to the healthcare applications, namely decentralization, privacy and security (Azbeg et al., 2021).

Blockchain had been used in several use cases in order to secure the data sharing between different healthcare stakeholders such as authorities from different hospitals or patient. Besides, the decentralization feature of blockchain is particularly useful for allowing data to be accessed and shared within the distributed healthcare entities to maintain decentralized management without having to rely on a central authority (Azbeg et al., 2021). Next, the immutability property owned by blockchain technology can prevent the data from being altered or stolen which will strengthen the security of healthcare database system. By using blockchain's cryptographic keys in the storage system, all the patient identity and privacy will be secured and protected (Azbeg et al., 2021).

#### 2.2.1(a) Electronic Health Record systems (EHR)

Most works have used Blockchain to handle Electronic Health Records (EHR) and share it in a secure manner (Azbeg et al., 2021). The EHR are the patients' medical information being collected and digitally stored. Blockchain is implemented to secure EHR and control the privacy of this data by requesting access from patients. The system is based on a permission-less blockchain and it ensures data authentication and confidentiality (Azbeg et al., 2021).

In EHR system, blockchain serves as a trusted ledger database to store a broad range of private healthcare data. Data privacy should be guaranteed and protected when

secure storage is achieved (Shi et al., 2020). Practically, healthcare data volume tends to be large and complex due to huge amount of patient related information to be recorded. Hence, a corresponding challenge is to find out the solution to deal with tremendous data storage without having discrepancies with the performance of blockchain network. However, if blockchain is applied appropriately in the EHR systems, it can help to maintain the security level of EHR systems, enhance the integrity and privacy of data, encourage organizations and individuals to share data, and facilitate both audit and accountability (Shi et al., 2020).

#### 2.2.1(b) Tracking Infectious Disease and Vaccine Supply Management (Applicable on Covid-19 Pandemic)

During the Covid-19 Pandemic, several technology companies around the world uses blockchain technology to develop some applications that help combating this crisis. Data sharing during the pandemic was secured by the application of blockchain integrating solution. A platform launched by WHO namely MiPasa that can facilitate the sharing of data among scientists, technologies, authorities, public health officials and other related front liners during this pandemic. This platform is created as a solution to assist and support the pandemic management and conquer the outbreak around the globe (Azbeg et al., 2021).

Before implementation of blockchain, the legacy Covid-19 vaccine scheme is considered fragile and not efficient due to the weakness in handling the vaccine distribution, tracking and registration system (Antal et al., 2021). The issues arise such as vaccine getting damage due to its transport condition, vaccine distribution and registration are lacking of systematic coordination, worker shortage and limited supply of vaccine. All these limitations will result in low level of security and privacy thus leading to delay and prolong the pandemic. In fact, the beneficiary must be provided safe and secure access to the vaccine and are eligible to report the side effects if any (Antal et al., 2021).

Therefore, in order to digitize and decentralize the existing vaccination supply system, a blockchain system which allows for transparent Covid-19 vaccine tracking, decentralized distribution monitoring and administration was proposed as shown in Figure 2-1 (Antal et al., 2021). Generally, the system uses distributed ledger for storing

vaccine data with immutability feature being assured. Figure 2-1 depicts the blockchain implementation in vaccination scheme with including all the main actors as peer nodes in this blockchain-based system. All the actions within the system are registered into the distributed ledger as immutable transactions which are stored in blocks that are connected to every peer actor in the chain (Antal et al., 2021). Hence, it will provide high transparency and security of the vaccination scheme that enabling the registration, tracking, monitoring and administration of the Covid-19 vaccine information as a digital asset (Antal et al., 2021).

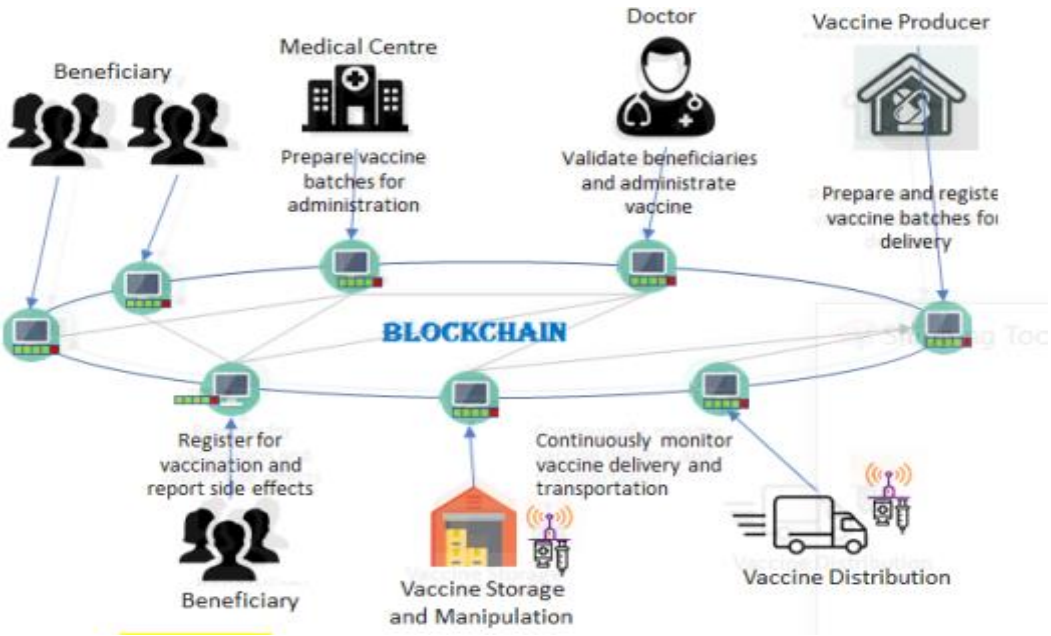


Figure 2-1 Interconnection within the blockchain implementation on Covid-19 immunization program management system including the process of vaccine registration, tracking, monitoring, administration and self-reporting (Antal et al., 2021).

### 2.2.2 Supply Chain Management System

Blockchain is a type of distributed ledger that can be used in a supply chain management system to build up trust in every transaction that had been made by people. Each record of every transaction is time stamped and attached to the chains one by one continuously (Sundarakani et al., 2021). In this way, blockchain bring benefits to the supply chain system, such as visibility, optimization, and demand (Lim et al., 2021). For instance, stakeholders who are authorized in a value chain are capable to access records on the blockchain only, which means the records can be shared and secured

simultaneously (Sundarakani et al., 2021). Managers can access data at lower risk because visibility and tracking of goods are assisted by the usage of sensors and by implementation of blockchain technology in supply chain management system. Blockchain adoption in supply chain is still nascent in many countries although it has undergone increase rate of research activities among the blockchain proponents (Sundarakani et al., 2021).

### 2.2.2(a) Blockchain and Supply Chain Relationship

Cryptography, consensus mechanism and smart contracts are three important structure of blockchain technology which can create value in supply chain. They are related to three major aspects of blockchain which are shareability, security and smart capabilities respectively. Upstream enterprises gain a deeper understanding of the needs of downstream customers with the help of data sharing through blockchain technology (Lim et al., 2021). Next, enterprises can make better decisions and are able to improve procurement management, production management, inventory management and many other links in supply chain since they can obtain timely data from the whole supply chain system, thus improving the overall performance of supply chain management. Furthermore, this publication stated that response and transaction time can be shortening when the permitted modification are allowed to be observed in real time by the mode of common recording across the entire network.

From the perspective view of security, blockchain technology possess immutable nature which prevent information from being changed, thus reduces the risk of the supply chain as well as improve the trust between the supply chain stakeholders. Customer trust can be build up by performing high product transparency and safety through blockchain technology. Firstly, the timestamp in the block provides chronological proof of a series of transactions. Next, Lim et al. (2021) reveals that modern sensors such as radio frequency identification (FRID) and global positioning system (GPS) have been integrated into blockchain system. These features owned by the blockchain-based supply chain system ensure traceability, safety and transparency of the product.

Smart contracts represent the smart attributes of blockchain. Smart contracts are executed quickly whereby the rights and interests of the participants are well protected under the terms of contract, thus improves the operational efficiency. Smart contracts